

CLAIMS

1. Apparatus for assaying an analyte of blood in a patient's blood vessel comprising:
a mounting module adapted so that it can be adhered to the skin of the patient overlying
5 a tissue region comprising the blood vessel;
a sensor unit mounted to the module that generates signals responsive to characteristics
of the tissue region; and
a controller that receives the signals and uses received signals to assay the analyte and
to determine a degree to which the sensor unit is aligned with the blood vessel.
- 10 2. Apparatus according to claim 1 wherein the sensor unit comprises at least one light
source that illuminates the region with light at at least one wavelength that is absorbed and/or
scattered by the analyte and generates photoacoustic waves in the region and at least one
acoustic transducer that generates at least some of the signals responsive to the photoacoustic
15 waves.
3. Apparatus according to claim 2 wherein the controller uses signals responsive to the
photoacoustic waves to assay the analyte.
- 20 4. Apparatus according to claim 2 or claim 3 wherein the light source illuminates the
region with light that is absorbed by red blood cells.
5. Apparatus according to any of claims 2-4 wherein the controller uses at least one
characteristic of the photoacoustic signals to determine a degree to which the sensor unit is
25 aligned with the blood vessel.
6. Apparatus according to claim 5 wherein the at least one characteristic comprises a
magnitude of the amplitude of the signal.
- 30 7. Apparatus according to claim 5 or claim 6 wherein the at least one characteristic
comprises shape of the signal.
8. Apparatus according to any of claims 5-7 wherein the at least one characteristic
comprises a time dependence of the signal.

9. Apparatus according to any of claims claim 5-8 wherein the at least one characteristic comprises a power spectrum of the signal.

5 10. Apparatus according to any of claims 2-9 wherein the controller controls the at least one transducer to transmit ultrasound into the region and wherein the at least one transducer generates at least some of the signals responsive to ultrasound reflected from features comprised in the region.

10 11. Apparatus according to claim 10 wherein the controller uses signals generated responsive to reflected ultrasound to determine a degree to which the sensor is aligned with the blood vessel.

12. Apparatus according to any of claims 2-11 and comprising a display screen.

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13. Apparatus according to claim 12 wherein the controller displays data that relates to a degree to which the sensor unit is aligned with the blood vessel on the display screen.

14. Apparatus according to claim 12 or claim 13 wherein the controller uses signals from
20 the at least one acoustic transducer to generate an image of the blood vessel and displays the image on the screen.

15. Apparatus according to claim 12 wherein the controller uses signals generated responsive to reflected ultrasound to generate an image of the blood vessel and displays the
25 image on the screen.

16. Apparatus according to claim 14 or claim 15 wherein the controller displays a fiducial on the screen and wherein a distance on the screen between the fiducial and the image of the blood vessel indicates a degree to which the sensor unit is misaligned with the blood vessel.

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17. Apparatus according to any of claims 1-16 wherein at least a portion of the sensor unit presses against the skin to provide optical and/or acoustic coupling of the sensor to the skin.

18. Apparatus according to claim 17 wherein the controller uses signals received from the sensor unit to determine if the sensor portion exerts excessive pressure on the blood vessel.

19. Apparatus for assaying an analyte of blood in a patient's blood vessel comprising:

5 a mounting module adapted so that it can be adhered to the skin of the patient overlying a tissue region comprising the blood vessel;

a sensor unit mounted to the module that generates signals responsive to characteristics of the tissue region wherein at least a portion of the sensor unit presses against the skin to provide optical and/or acoustic coupling of the sensor to the skin;

10 a controller that receives the signals and uses received signals to assay the analyte and to determine if the sensor portion exerts excessive pressure on the blood vessel.

20. Apparatus according to claim 19 wherein the sensor unit comprises at least one light source that illuminates the region with light at at least one wavelength that generates
15 photoacoustic waves in the region and at least one acoustic transducer that generates at least some of the signals responsive to the photoacoustic waves.

21. Apparatus according to claim 20 wherein the controller controls the at least one transducer to transmit ultrasound into the region and wherein the at least one transducer
20 generates at least some of the signals responsive to ultrasound reflected from features comprised in the region.

22. Apparatus according to any of claims 18-21 wherein the controller uses the signals to generate an image of the blood vessel and if the image indicates that the blood vessel is
25 deformed relative to a normative blood vessel shape, the controller determines that the sensor portion exerts excessive pressure.

23. Apparatus according to any of claims 18-22 wherein the sensor portion position is movable relative to the mounting module in a direction substantially perpendicular to the skin
30 so as to adjust pressure that the sensor unit portion exerts on the skin and thereby on the blood vessel.

24. Apparatus according to claim 23 wherein the position of the sensor portion is manually adjustable.

25. Apparatus according to claim 23 or claim 24 and comprising a motor controllable to adjust the position of the sensor unit portion.

5 26. Apparatus according to claim 25 wherein the controller controls the motor to adjust position of the sensor unit portion if the controller determines that the sensor unit portion exerts excessive pressure on the skin.

10 27. Apparatus according to any of claim 2-26 wherein the mounting module comprises a frame having sides, which at least partially surround a region that receives the sensor unit.

28. Apparatus according to claim 27 wherein the region that receives the sensor unit is an open region and when the sensor unit is positioned in the region no portion of the mounting module intervenes between the sensor unit and the skin.

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29. Apparatus according to claim 28 and comprising an adhesive that attaches the sensor unit to the skin when the sensor unit is mounted in the open receiving region.

20 30. Apparatus according to claim 29 wherein the adhesive is substantially transparent to light provided by the at least one light source.

31. Apparatus according to claim 29 or claim 30 wherein the adhesive is a relatively good conductor of sound and reduces acoustic impedance mismatch between the sensor unit and the skin.

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32. Apparatus according to claim 28 and comprising a gel that optically and acoustically couples the sensor unit to the skin when the sensor unit is mounted in the open receiving region.

30 33. Apparatus according to claim 27 wherein the frame comprises a panel that connects the sides and which intervenes between the sensor unit and the skin when the sensor unit is mounted in the receiving region.

34. Apparatus according to claim 33 wherein the panel is flexible.

35. Apparatus according to claim 33 or claim 34 wherein the panel is substantially transparent to light provided by the at least one light source.

5 36. Apparatus according to any of claims 33-35 wherein the panel is a relatively good conductor of sound.

37. Apparatus according to any of claims 33-36 wherein the panel comprises an adhesive layer that bonds the panel and thereby the mounting module to the skin.

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38. Apparatus according to claim 37 wherein the adhesive is substantially transparent to light provided by the at least one light source.

15 39. Apparatus according to claim 38 wherein the adhesive is a relatively good conductor of sound and reduces acoustic impedance mismatch between the panel and the skin.

40. Apparatus according to any of claims 33-39 and comprising a gel or oil that optically and acoustically couples the sensor unit to the panel when the sensor unit is mounted in the receiving region.

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41. Apparatus according to any of claims 33-40 wherein the frame comprises at least one elastic element that exerts a resilient force on the sensor unit substantially parallel to the plane of the frame to maintain the sensor unit securely in position in the frame.

25 42. Apparatus according to claim 41 and comprising at least one set screw having a position that limits motion of the sensor unit in a direction that the resilient force operates to move the sensor unit.

43. Apparatus according to claim 42 wherein the set screw is mounted in the frame.

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44. Apparatus according to claim 42 or claim 43 wherein the position of the set screw is adjustable manually.

45. Apparatus according to claim 42 or claim 43 and comprising a motor controllable to adjust the position of the set-screw.

5 46. Apparatus according to claim 45 wherein the controller controls the motor to adjust position of the sensor unit if signals received from the sensor unit indicate alignment of the sensor unit is unsatisfactory.

10 47. Apparatus according to any of claims 1-26 and comprising a motor controllable to adjust the position of the sensor unit relative to the mounting module in a direction parallel to the skin and wherein the controller controls the motor to adjust position of the sensor unit if signals received from the sensor unit indicate alignment of the sensor unit is unsatisfactory.

48. Apparatus according to any of claims 1-47 wherein the analyte is glucose.